Technological Developments Supporting Deployment of EV Charging Infrastructures

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Abstract

Although the electric vehicles (EVs) are expected to be marketed as clean vehicles without emissions, the preparation of charging infrastructures will be an essential requirement for their popular acceptance. NEC is developing an EV charging infrastructure system that is equipped with remote operation/maintenance and energy control functions as well as an authentication/billing function. This will allow the business operators to install and operate charging stations efficiently and safely. In addition, NEC is also advancing activities for standardizing the system interfaces between various vendors for making the charging stations usable by anyone regardless of the system vendors or business operators. This paper introduces our activities for supporting the preparation of EV charging infrastructures.

Keywords

electric vehicle (EV), quick charger, cloud, charging station, smart grid

1. Introduction

EVs are recently attracting attention as environmentally-friendly vehicles with zero emissions and they are currently being introduced on a global scale. Nevertheless, to promote their deployment on a wider level, it is essential to prepare charging infrastructures so that anyone can charge their EV anywhere and at anytime. At NEC, in order to promote preparation of suitable charging facilities, we are developing an EV charging infrastructure system that enables various business operators to install and operate charging stations efficiently and securely. Additionally, we are also developing joint activities with national and local governments aiming at standardizing communication interfaces between various vendors so that anyone can use charging stations at various locations regardless of the system vendors (hereafter referred to as "vendors") or business operators. This paper introduces the NEC activities for supporting the preparation of charging infrastructures.

2. Issues for the Preparation of EV Charging Infrastructures

Unlike the petrol/gas stations, EV charging stations can be installed at any place where electricity is available. This condition is expected to stimulate the participation of various business operators in the future and support the installation of charging stations at various locations, including at commercial, entertainment and traffic facilities.

Not a few of these charging stations may be used in unattended operations. However, some of the charging stations currently under unattended operation require high operational costs because of the necessity for periodical maintenance personnel visits to check the working status and to collect the usage logs etc. In addition, the difficulty of making rapid changes to the operational settings of the chargers such as for output power, hinders operations that can effectively match the recent power supply circumstances. In consideration of these facts, it is important to provide functions for remote executions of the above operations in order to enable unattended operations satisfactorily.

Furthermore, since most of the current charging stations are installed for the purpose of demonstration, they are not equipped with billing mechanisms and charging services are free. In the future, however, it will be necessary to collect the proper service charges from users in order to promote independent, continual growth of the charging infrastructure market. This will increase the importance of the authentication/billing function that will also enable business operators to provide various billing menus for the convenience of the users.

A new issue emerging currently in addition to those referred to above is that of the interconnection among different

vendors and also among different business operators. The majority of currently installed charging stations are based on individual specifications of vendors and business operators, and there is no common communication standard for linkage between them. This has resulted in a situation in which the differences between business operators regarding membership cards entitling use of a charger makes it impossible to receive the service without the appropriate membership card of each charging station. In addition, the charging station map information including the location and availability information is currently managed by an individual vendor or business operator, making it difficult for a user to obtain information regarding the overall situation.

To solve the issues referred to above, we are developing an EV charging infrastructure system, that enables the business operators to install and operate charging stations efficiently and securely by linking rapid chargers equipped with communication functions via a cloud computing system. Additionally, we are also developing joint activities with national and local governments aiming at standardizing the communication interfaces. Below, we introduce the EV charging infrastructure system in section 3 and our activities at NEC for implementing the standards of communication interfaces in section 4.

3. EV Charging Infrastructure System

3.1 Outline of the EV Charging Infrastructure System

The EV charging infrastructure system is intended to offer implementation of smart EV charging stations. **Fig. 1** shows the outline of the system. This system provides the remote operation/maintenance and energy control functions that enable efficient maintenance and output control of chargers from distant locations such as from the call center or the business operator's office. It also offers an authentication/billing function that provides various billing menus as well as other functions improving user convenience. The details of each function will be described below.

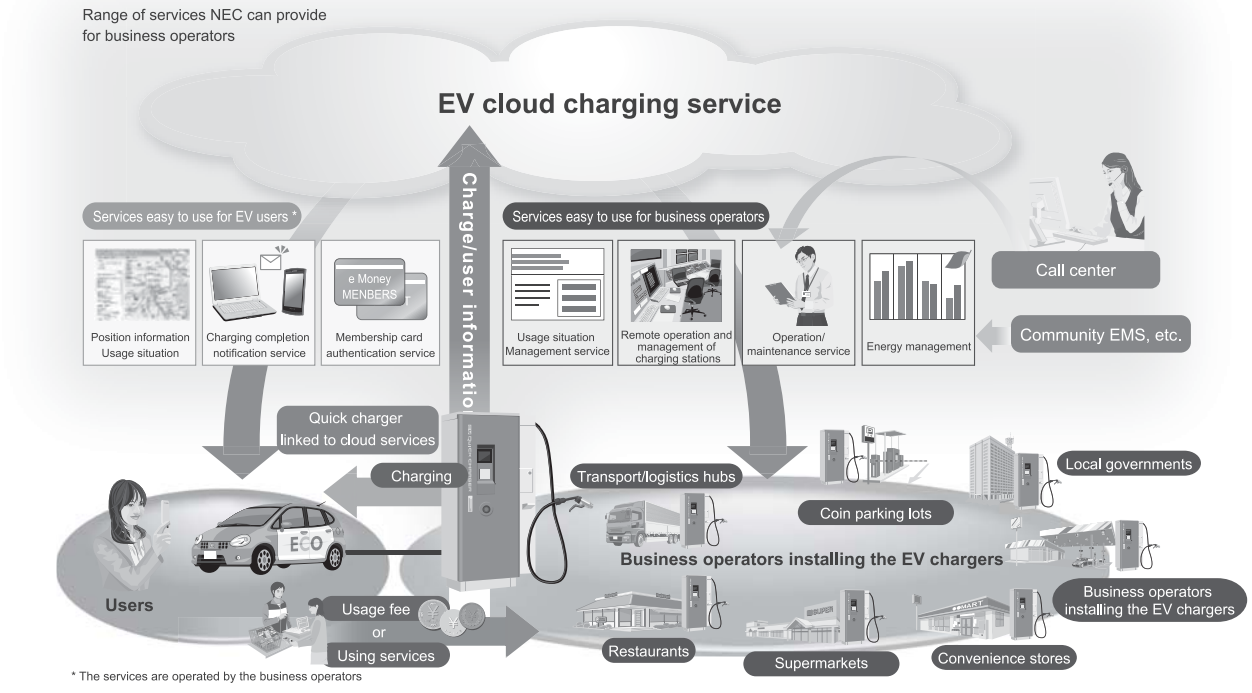

Fig. 1 Outline of the EV charging infrastructure system.

3.2 Function Details

(1) Remote operation/maintenance and energy control functions

Linkage between quick chargers equipped with a communication function and the cloud service enables the business operators to monitor permanently the operation and fault information of quick chargers in the charging stations. This function is also capable of remote switching of the operational status of a charger or remote maintenance including software updating. This enables fault countermeasures to be applied, and to expand the charger features and support operations from a remote location by the EV user.

The output of a quick charger can be controlled flexibly from the cloud service, etc. The business operator can remotely control the output values of quick chargers at charging stations by considering the local power demand-supply conditions, etc. Automated control based on a pre-set schedule is also possible.

In the future, flexible energy control applications meeting the needs of the age of the smart grid will also be possible, for example linking of the quick chargers with the energy management systems in public facilities, buildings, stores and apartment blocks to enable more economical operation.

As seen in the above, this function enables the business operators to install and operate charging stations efficiently and securely even if they are not dedicated facilities attended permanently by staff as is the case with the petrol/gas stations.

(2) Authentication/billing function

The quick charger incorporates a multi-service reader/writer to enable member authentication using the FeliCa card and billing with e-money (**Fig. 2**). Billing using e-money can offer a variety of e-money settlement functions based on linkage with the cloud-type e-money settlement service provided by NEC. A usage situation management service is also provided to manage member usage in the cloud computer and to report data to business operators each month. As the business operators can bill charges and offer the achieved charges to users based on the information obtained above, so this function can be applied to settlements via other means than with e-money, for example by withdrawal from the users' bank accounts.

As seen above, this system makes it possible to set various billing menus for charging fees. The business operators can set the menus from a remote location in linkage with the cloud service.

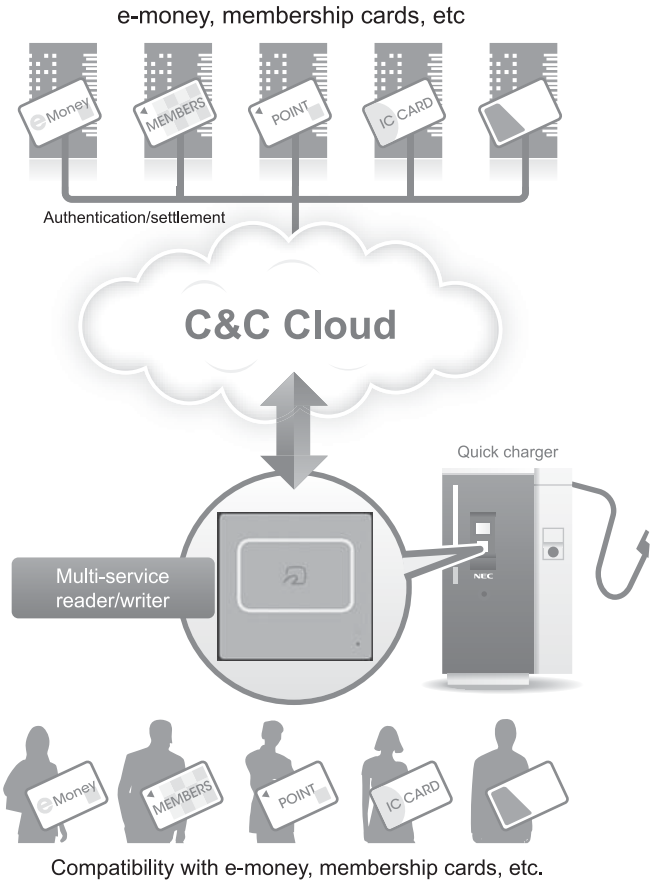

Fig. 2 Scheme of linkage with e-money settlement service.

(3) Functions for improving user convenience

The system also features various functions for providing services that can improve the convenience of users. The "charging station map" (**Fig. 3** and **Fig. 4**) displays the charger location information and current usage situation (occupied/idle information) and allows a user in a remote location to find an available charger using a PC, mobile phone or car navigation system. The map can also be used to select a charging station and make an advance reservation on the charger reservation display (**Fig. 5**), so that a user may plan use of chargers and avoid congestion. There is also a function that sends an e-mail notifying completion of charging to the

Fig. 3 Example of charging station map display (for PC).

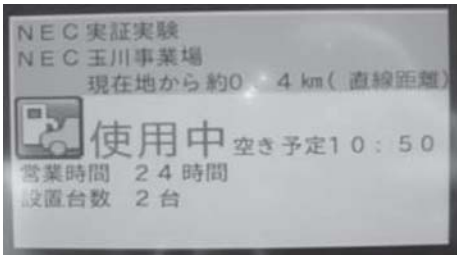

Fig. 4 Example of charging station map display (for car navigation system).

user so that the user can immediately know of the completion of charging if he or she is spending time during charging at a location apart from the EV.

4. Communications Standardization Strategy

At NEC, we are planning to standardize communication interfaces between various vendors so that the charging stations being introduced widely can be used by anyone and at anytime, regardless of the vendors or business operators.

In the Smart Network Project adopted by Japan's Ministry of Internal Affairs and Communications as a part of the Project to Standardize and Promote Network Integration Control Systems, we achieved interconnection with the system provided by another vendor for the purpose of member authentication. We also connected quick chargers of several manufacturers

Fig. 5 Example of charger reservation display (for mobile phone).

(Takasago, Ltd. in the NEC Group, NTT FACILITIES, INC., Nissan Motor Co., Ltd., etc.) to the cloud and performed remote operation/maintenance from the call center and performed an evaluation experiment on the practicality and universality of a communication standard that we were studying. At present, we are participating in a demonstration experiment of billing and fee collection models for charging stations installed or subsidized by local governments as part of the E-KIZUNA Project, which is an EV dissemination project promoted by Saitama city. In this project, we are studying and verifying communication standards for use in interconnection with major vendors and business operators in Japan.

5. Conclusion

This paper introduced the activities of the NEC Group for supporting the preparation of EV charging infrastructures. NEC will continue to support various business operators in the

installation and operation of charging stations based on our EV charging infrastructure system. We will also advance mechanisms for interconnection between different vendors and carriers aiming at the implementation of a society in which anyone can charge his or her EV anytime and anywhere.

*FeliCa is a registered trademark of Sony Corporation.

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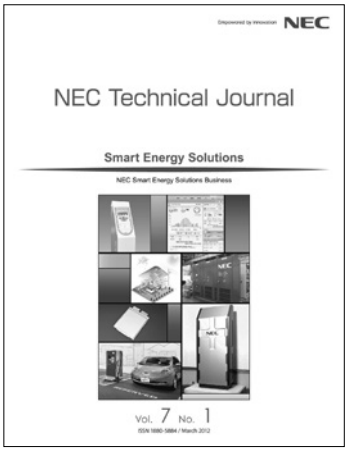

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